AD-A170 865 EVALUATION OF THE SELF-BORING PRESSUREMETER IN SAND(U) 1/1
CENTRO DI RICERCA IDRAULICA E STRUTTURALE MILAN (ITALY)
R BELLOTTI ET AL. FEB 86 R/D-4227-EN-01

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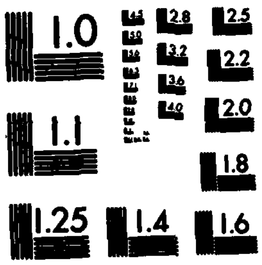

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AD-A170 865

Research Project:

"Evaluation of the Self-Boring Pressuremeter in Sand"

Principal Investigators:

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ENEL C.R.I.S. - MILANO (Italy)

Contractor Number:

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THIRD INTERIM REPORT

(June 1985 through Febr. 1986)

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1. PRESENT RESEARCH STATUS

During the period covered by this report the writers performed the following work:

a. No. 20 SBPT's in dry Ticino (TS) and Hokksund (HS) sands. A summary of the results of these tests is given in Table 1. These tests were performed using the so called "ideal installation" meaning that the SBP probe was installed in the calibration chamber before the specimen was formed by pluviation.
These tests complete the programme of tests in dry sand using ideal installation.

b. Starting from test No. 225 the Camkometer probe with the modified strain arms was used with the aim of detecting more reliably the lift-off pressure p_o that under ideal conditions should correspond to the horizontal stress σ'_h applied at the external boundary of the CC specimen.
The modifications of the strain arms consisted in :

- substitution of the original arms made of brass with new re-designed arms of steel, having a larger rigidity.
- attempting to reduce the mechanical clearance seated in the original pivot-bush system by the insertion of a miniature roller bearing instead of the original bushing.
- improving the planarity and reciprocal alignement of the pivot and arms seating.

Successively more rigid springs pushing the arms into their zero position were introduced and further improvements in the planarity and the reciprocal alignement of both pivot and arms seating were made.

All this was accomplished with the aim of reducing the observed mechanical compliance of the strain arms that obliterates the true value of the measured p_o.

Tests No. 201 to No. 224 were performed using a probe equipped with the original arms, see examples in Figs. 1 and 2.

Tests No. 225 to No. 228 were performed using the probe with the re-designed strain arms, see examples in Figs. 3 and 4.

Starting from test No. 233 the probe equipped with the last version of the modified and improved strain arms was used; see examples in Figs. 5 and 6.

The comparison of the initial part of the expansion curves shown in a very enlarged scale indicates that while the mechanical compliance of the strain arms has been reduced, their performance is still not completely satisfactory.

c. In order to ascertain that during the 1-D straining performed with the SBP already embedded in the CC there is no stress concentration around it, a test has been performed using the rigid Cambridge In-Situ K_o- cell. The results of this test are summarized in Fig. 7 and show that apart from some non-linearity and hysteresis of the device, the measured horizontal stress on the surface of the K_o- cell substantially equals the horizontal stress applied at the boundary of the CC specimen.

2. RESEARCH PLANS

a. Further improvements of the strain arms will be tried with the aim of achieving a better reliability of the p_o assessment. This will require the execution of a limited number of additional SBPT's in dry sand.

b. The modification of the top of the CC in order to allow for the testing of the self-boring process, is in advanced state of design.

c. A preliminary series of CC tests will start with the SBP probe inserted by means of the self-boring process using the same techniques as used in the field. This will require performing the tests on saturated specimens thus slowing down the progress of the present research.

d. Analysis of the tests already available performed in dry sand with the aim of:

. determining the influence of the finite dimensions of the CC on the results of the SBPT's;

. working out the criteria that will allow to relate the different pressuremeter shear moduli G to the relevant design problems. This will bring up questions like the influence of stress and strain levels on measuring models and consideration due to the problem of sand anisotropy;

. critical examination of the reliability of the usual assumption that p_o equals σ'_h also in sand;

. comparison of measured values of G against other laboratory moduli obtained on pluvially deposited specimens of the test sands;

. evaluation of the reliability of the plane strain angle of shearing resistance ϕ'_{PS} that may be obtained from expansion tests in sands using Rowe's stress dilatory theory.

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3. MISCELLANEA

The writers co-operating with other European research centers using the CC for the validation of in-situ devices, have organized in Milan a second informal seminar on the progress made in this type of research. The meeting will take place at ENEL C.R.I.S. Laboratories in Milan on March 18 and 19, 1986.

The Norwegian Geotechnical Institute and the Universities of Oxford, Chalmers (Gōteborg, Sweden), British Columbia (Vancouver, Canada) Sydney (Australia), Grenoble (France), Louisiana (Baton Rouge, USA) are scheduled to attend the seminar.

SYMBOLS APPEARING IN TABLE 1

BC	=	Boundary conditions applied to the CC specimens
B-1	=	BC with constant boundary stresses σ'_h = CONST., σ'_v = CONST.
γ	=	Dry bulk density
D_R	=	Relative density
OCR	=	Overconsolidation ratio
σ'_v	=	Vertical stress } Applied to CC specimens
σ'_h	=	Horizontal stress } Applied to CC specimens
K_o	=	Coefficient of earth pressure at rest
p_{lim}	=	Ultimate cavity pressure from Log p vs. Log $\frac{\Delta v}{v}$ plot
G_{ur}	=	Unloading-reloading shear modulus(*)
p_B	=	Corrected cavity stress at which unload-reload loop starts
$\Delta\gamma$	=	Shear strain amplitude of the loop
M	=	Constrained modulus(**) measured during the 1-D straining of the CC specimen

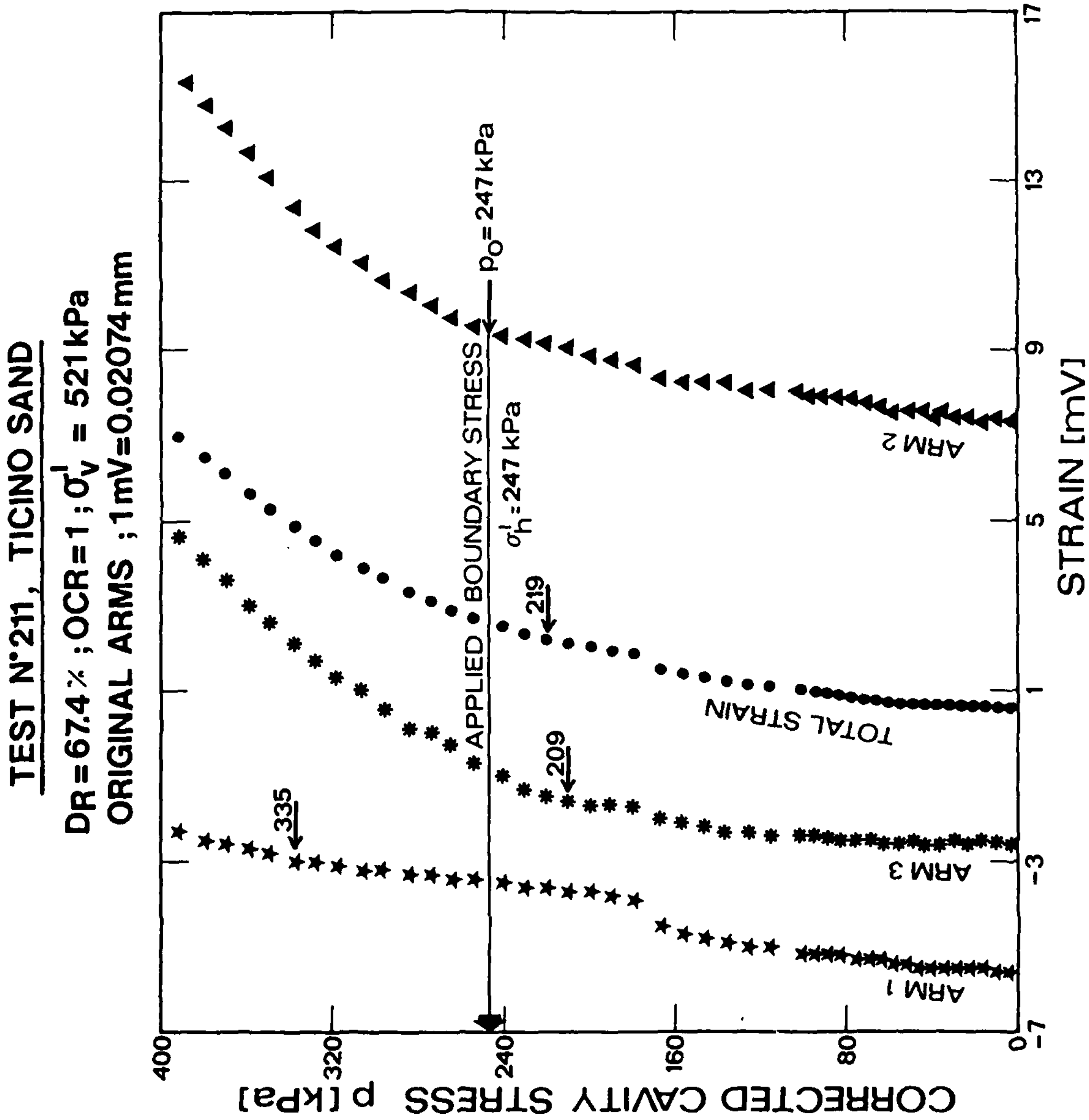
(*) Numerals indicate the number of the loop

(**) Tangent modulus for NC specimens and secant modulus representing the whole unloading loop for OC specimens

Table 1: SBPT's performed in CC on dry Ticino and Hokksund sands

TEST	BC	γ	D_R	OCR	σ'_v	σ'_h	K_o	P_o	P_{lim}	G_{UR1}	P_3	$\Delta\gamma$	G_{UR2}	P_B	$\Delta\gamma$	G_{UR3}	P_B	$\Delta\gamma$	M	SAND
n°	-	$\frac{kPa}{m^3}$	%	-	kPa	kPa	-	kPa	MPa	MPa	kPa	%	MPa	kPa	%	MPa	kPa	%	MPa	
201	B-1	16.07	67.0	2.8	113	75	0.66	76.1	1.47	47.68	259	0.25	50.72	421	0.24				182.2	HS
207	"	15.33	43.9	3.3	110	65	0.59	65.0	0.88	36.18	251	0.21	36.21	306	0.26				176.9	HS
208	"	14.81	43.2	1.0	113	45	0.40	28.1	0.52	25.16	119	0.21	27.33	148	0.20				34.1	TS
209	"	14.99	49.2	1.0	117	51	0.44	46.0	0.69	34.47	136	0.14	36.93	169	0.13	40.84	224	0.14	43.6	TS
210	"	15.11	53.3	1.0	511	245	0.48	81.2	2.65	75.75	537	0.13	79.32	650	0.12	79.40	763	0.13	100.1	TS
211	"	15.56	67.4	1.0	512	242	0.47	58.1	2.84	72.42	496	0.13	79.04	653	0.13	81.56	811	0.13	114.9	TS
212	"	15.47	64.6	2.9	111	83	0.75	104.3	1.40	47.99	273	0.14	50.60	367	0.14	52.30	478	0.15	180.0	TS
213	"	14.87	47.5	2.8	113	84	0.74	120.3	1.10	47.91	263	0.15	48.66	348	0.13	51.45	407	0.14	168.6	TS
214	"	14.73	42.4	1.0	112	54	0.48	49.2	0.80	32.30	140	0.16	34.69	186	0.16	36.84	235	0.16	508.0	TS
215	"	16.32	92.3	1.0	515	227	0.44	254.4	3.68	93.70	549	0.078	93.90	722	0.14	105.88	884	0.13	143.7	TS
216	"	14.81	46.3	7.7	61	57	0.93	73.3	0.73	40.96	207	0.14	42.04	254	0.13	40.89	304	0.13	156.8	TS
218	"	15.43	65.4	7.7	72	71	0.99	80.2	0.78	45.89	259	0.18	46.08	313	0.14	47.16	367	0.063	169.6	TS
219	"	15.51	65.9	5.4	113	101	0.90	131.4	1.60	61.62	348	0.14	61.38	434	0.15	65.03	537	0.16	207.5	TS
220	"	14.93	47.2	1.0	313	148	0.47	139.1	1.24	51.44	329	0.13	50.89	388	0.12	54.20	455	0.13	80.1	TS
221	"	14.85	44.6	2.9	109	82	0.76	68.3	1.06	45.69	265	0.13	44.13	317	0.12	48.63	372	0.12	173.4	TS
222	"	14.90	46.2	5.5	112	96	0.86	141.4	1.21	53.84	315	0.13	51.61	395	0.13	51.62	469	0.13	199.0	TS
224	"	15.79	74.6	5.4	114	93	0.82	124.9	1.72	61.1	317	0.13	62.47	412	0.13	58.67	490	0.23	222.4	TS
225	"	15.79	74.6	5.5	113	88	0.79	96.4	1.58	48.64	319	0.19	52.36	416	0.14	54.26	499	0.14	218.3	TS
228	"	15.82	75.7	1.0	518	215	0.42	208.0	2.99	67.30	443	0.13	70.83	537	0.13	77.83	630	0.12	120.3	TS
233	"	15.83	75.7	1.0	518	216	0.44	219.0	2.94	66.09	434	0.14	75.5	541	0.13	78.7	654	0.14	121.3	TS

Fig. 1



TEST N°211, TICINO SAND
DR=67.4% ; OCR=1 ; σ'v = 521 kPa
ORIGINAL ARMS ; 1 mV=0.02074 mm
APPLIED BOUNDARY STRESS
σ'h=247 kPa
po=247 kPa
335
209
219
ARM 1
ARM 3
TOTAL STRAIN
ARM 2
STRAIN [mV]
CORRECTED CAVITY STRESS p [kPa]

TEST N° 224, TICINO SAND

$D_R = 74.6\%$; OCR = 5.4 ; $\sigma'_v = 116$ kPa
ORIGINAL ARMS ; 1 mV = 0.02134 mm

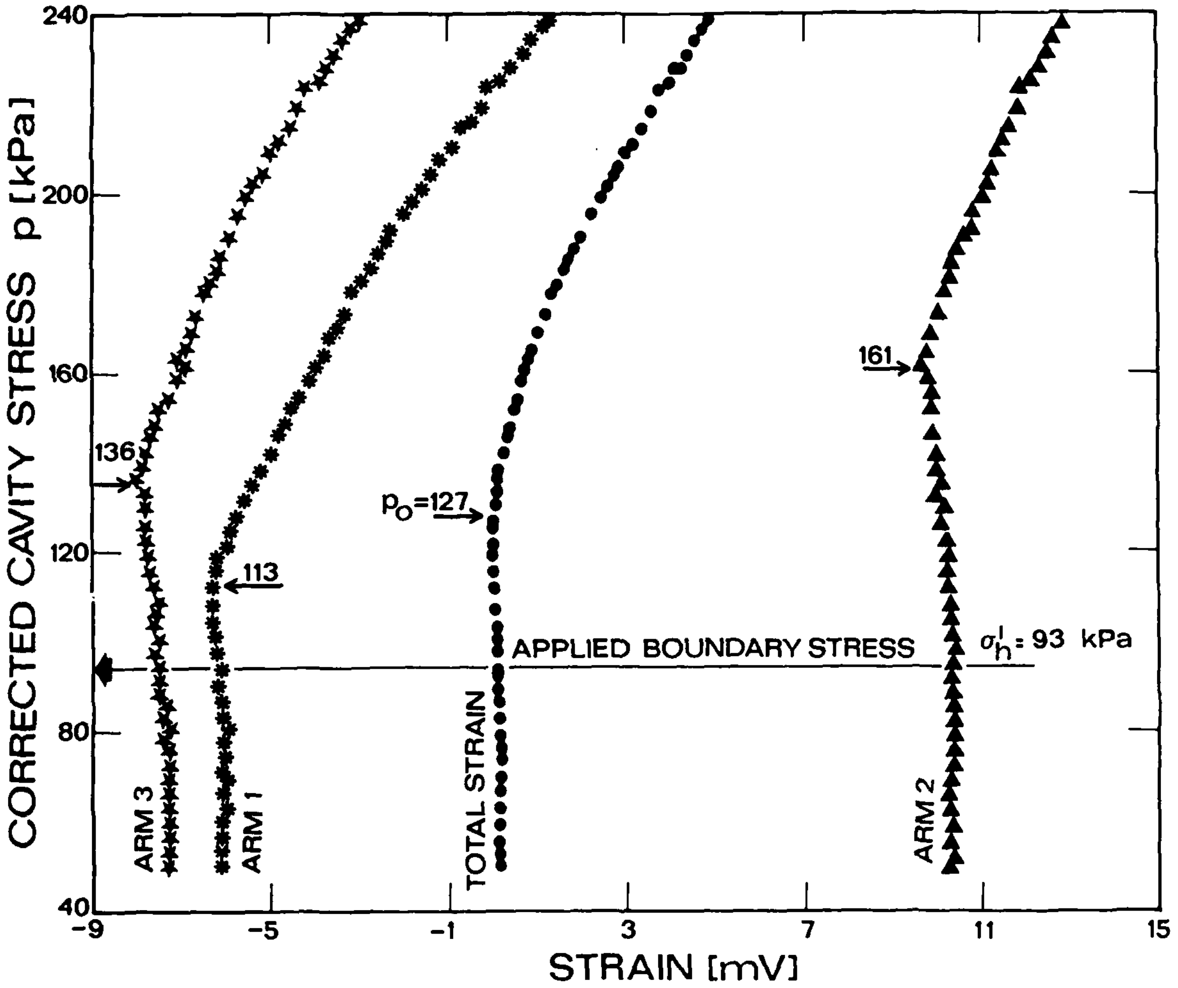
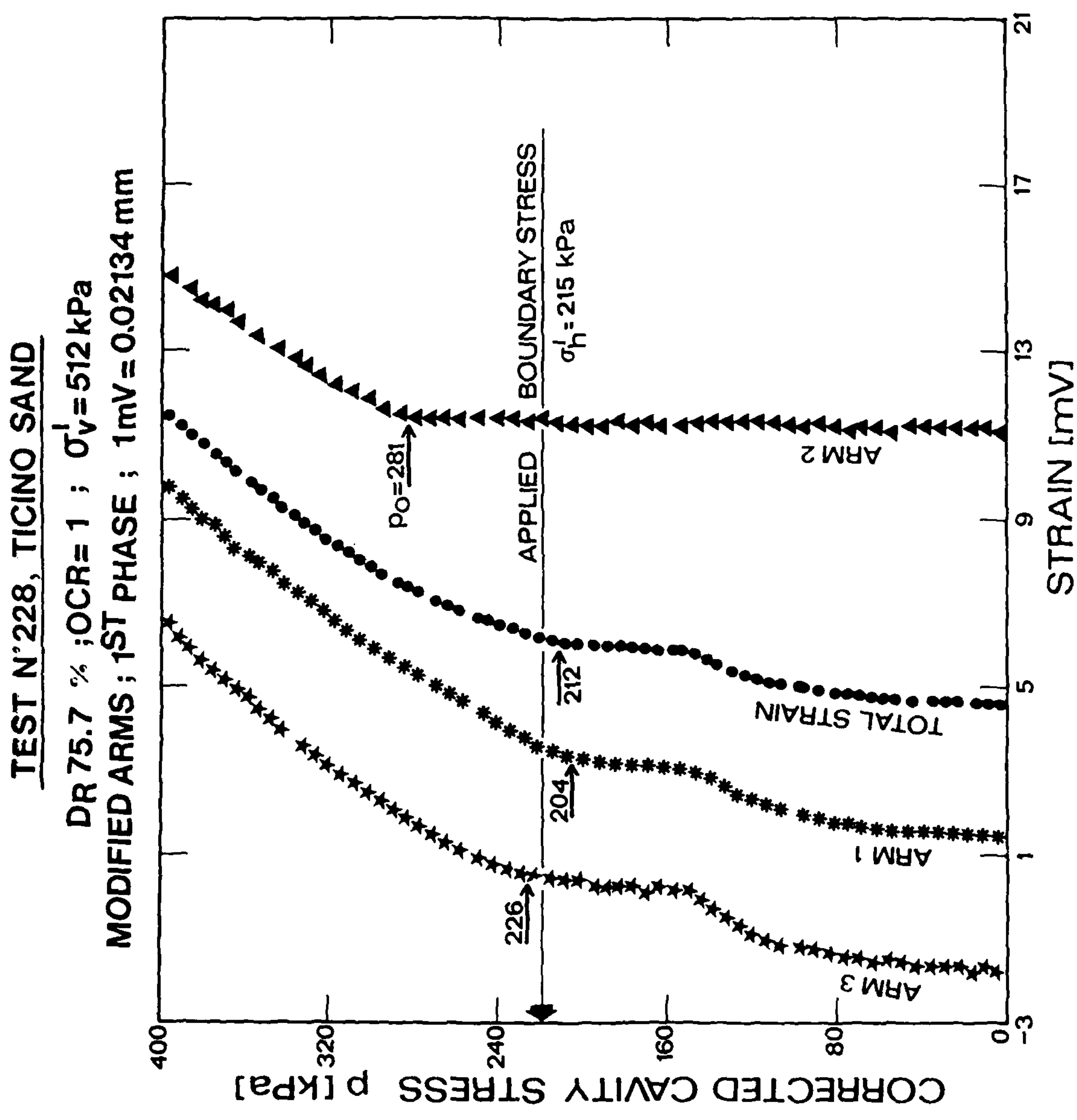


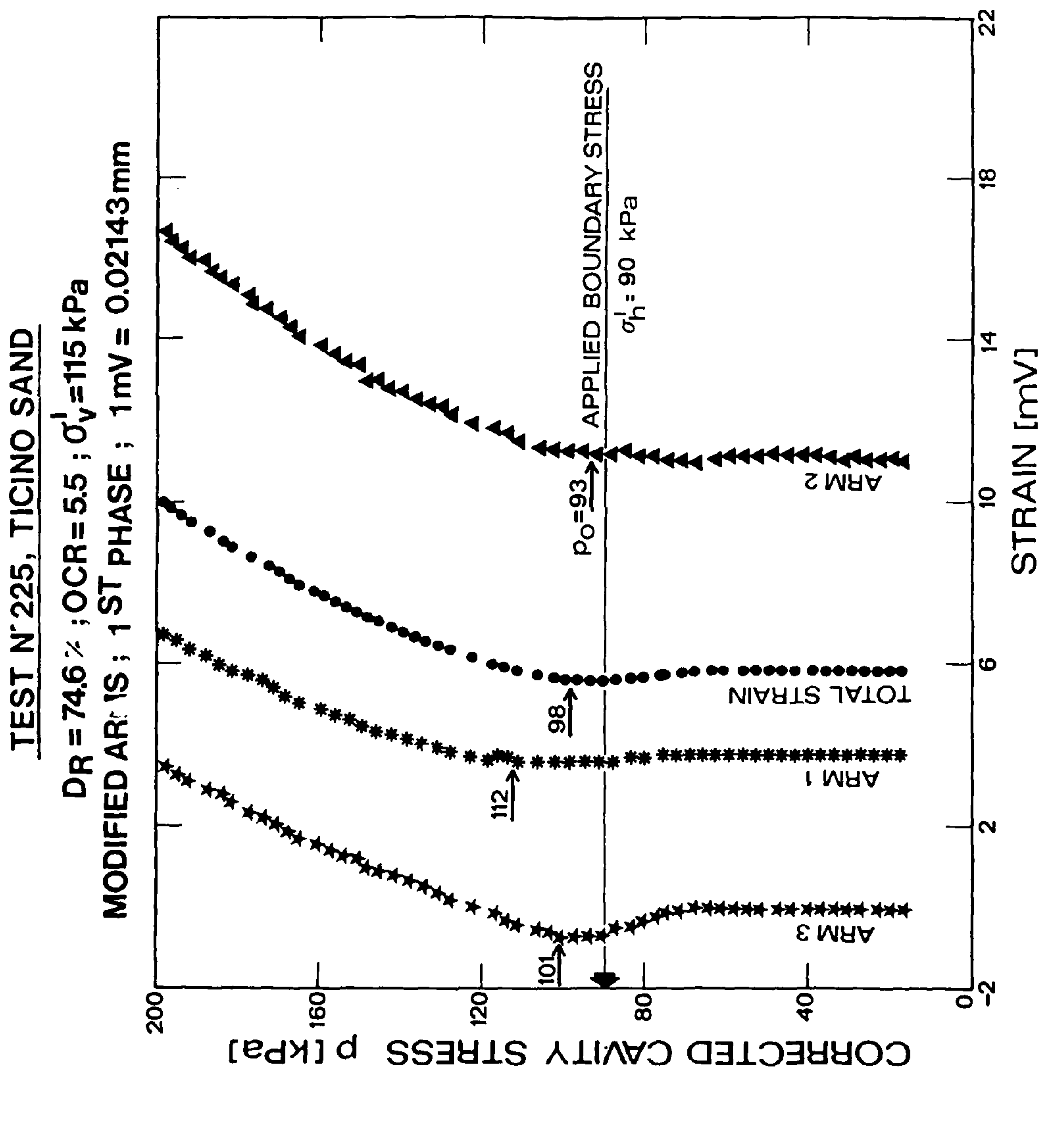
Fig. 2

Fig. 3



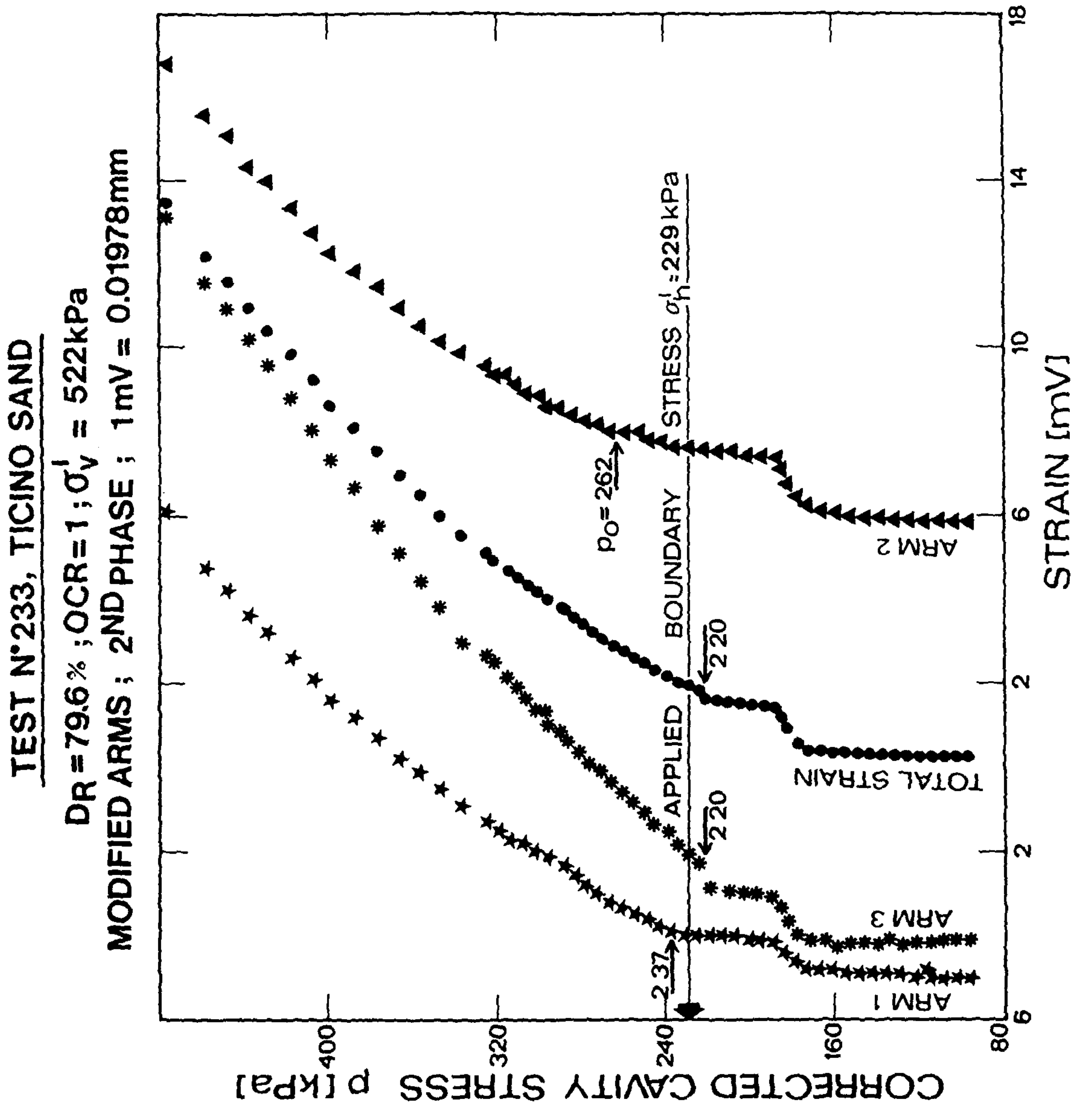
TEST N'228, TICINO SAND
DR 75.7 % ;OCR= 1 ; σ'v=512 kPa
MODIFIED ARMS ; 1ST PHASE ; 1mV=0.02134 mm
APPLIED BOUNDARY STRESS
σ'h=215 kPa
po=281
212
204
226
ARM 2
TOTAL STRAIN
ARM 1
ARM 3
CORRECTED CAVITY STRESS p [kPa]
STRAIN [mV]
400
320
240
160
80
0
-3
1
5
9
13
17
21

Fig. 4



TEST N°225, TICINO SAND
D_R = 74.6 % ; OCR = 5.5 ; σ'_v = 115 kPa
MODIFIED ARMS ; 1 ST PHASE ; 1 mV = 0.02143 mm
APPLIED BOUNDARY STRESS
σ'_h = 90 kPa
p_o=93
98
112
101
ARM 2
TOTAL STRAIN
ARM 1
ARM 3
STRAIN [mV]
CORRECTED CAVITY STRESS p [kPa]

Fig. 5


TEST N°233, TICINO SAND
D_R = 79.6 % ; OCR = 1 ; σ'_v = 522kPa
MODIFIED ARMS ; 2ND PHASE ; 1mV = 0.01978mm
APPLIED BOUNDARY STRESS σ'_h = 229 kPa
p_o = 262
237
220
220
ARM 1
ARM 3
TOTAL STRAIN
ARM 2
CORRECTED CAVITY STRESS p [kPa]
STRAIN [mV]
80
160
240
320
400
6
2
2
6
10
14
18

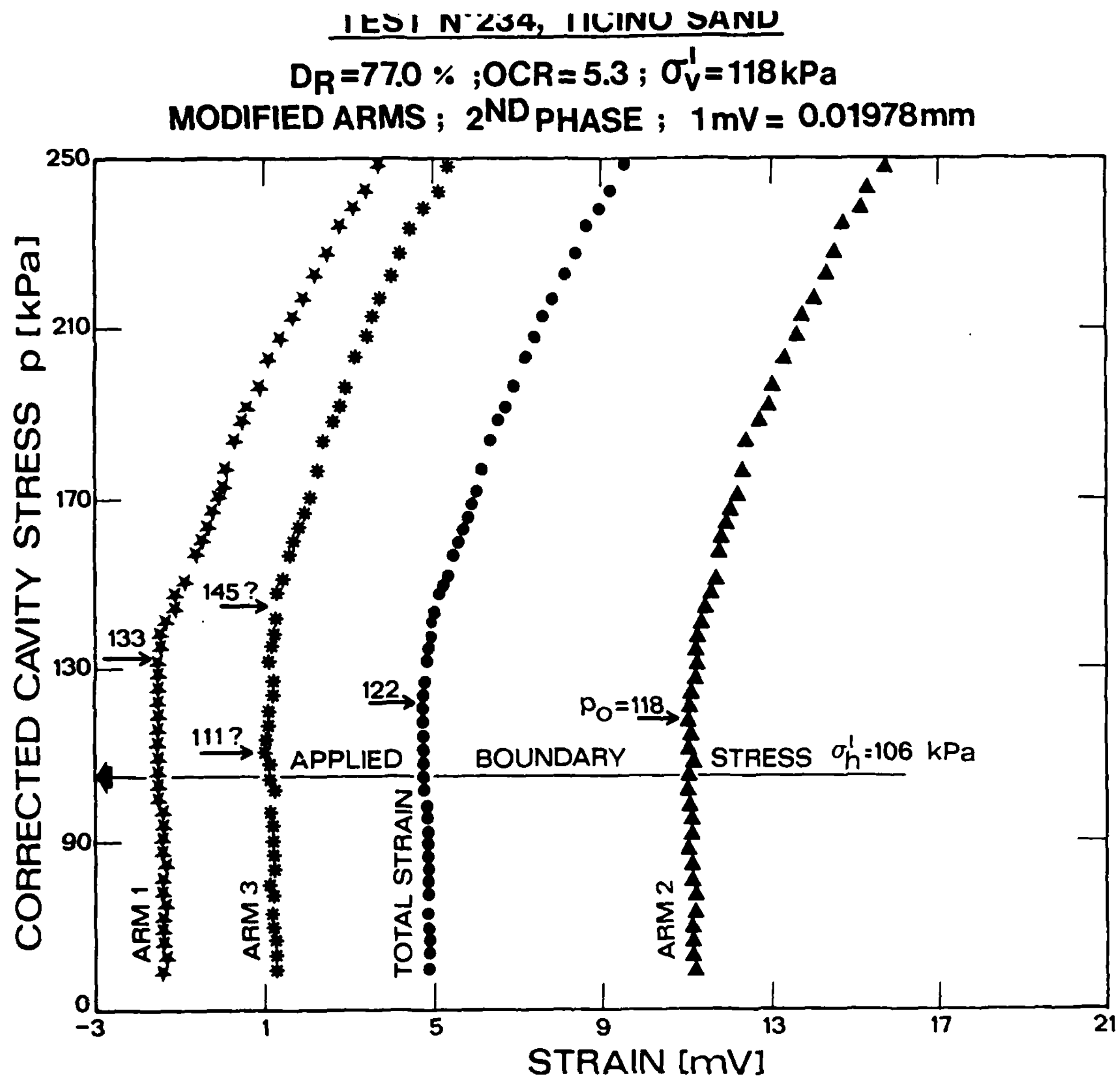
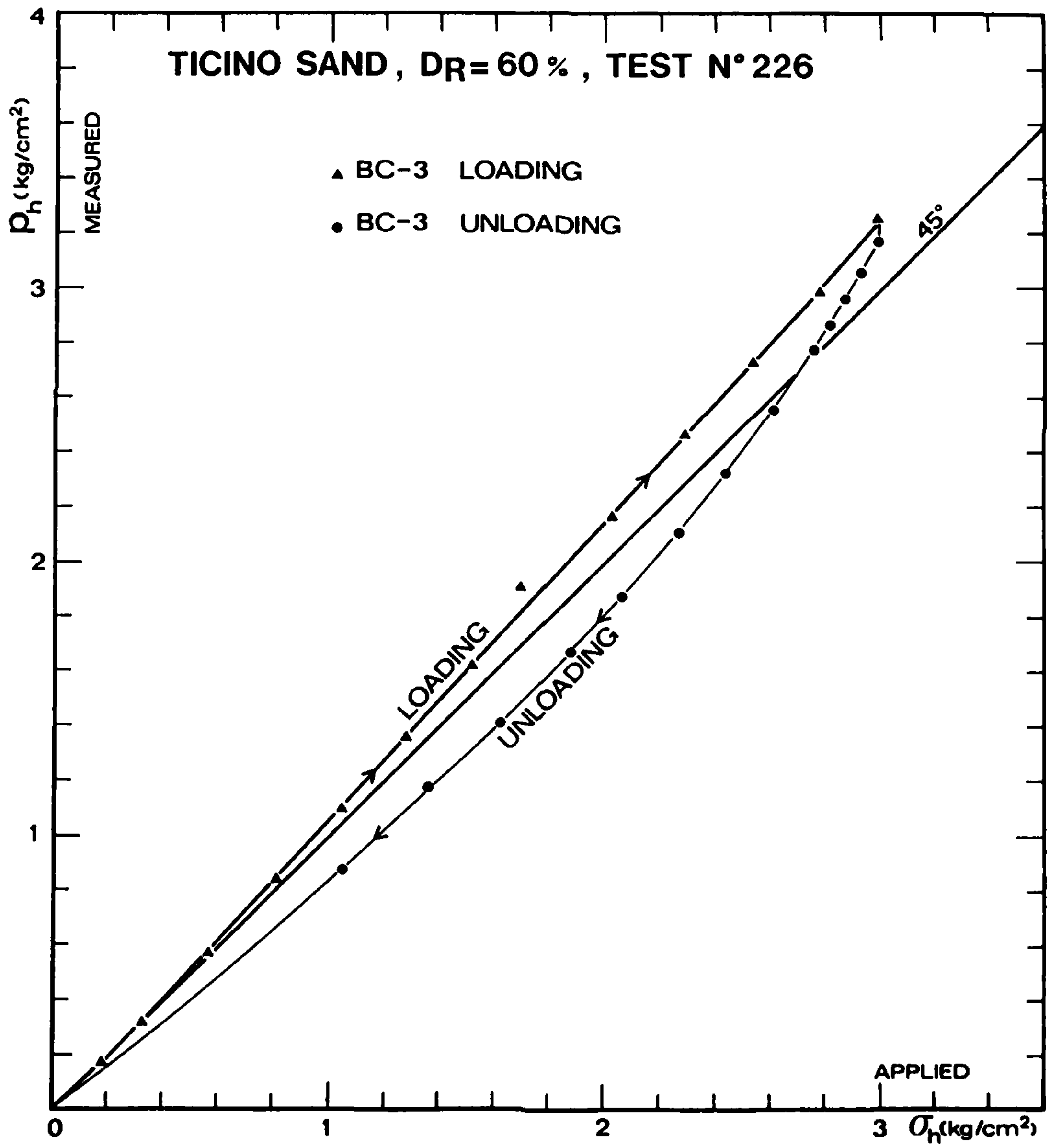

TEST N°234, TICINO SAND
D_R=77.0 % ;OCR=5.3 ; σ'_v=118 kPa
MODIFIED ARMS ; 2ND PHASE ; 1 mV = 0.01978mm
CORRECTED CAVITY STRESS p [kPa]
STRAIN [mV]
250
210
170
130
90
0
-3
1
5
9
13
17
21
133
145 ?
111 ?
122
p_o=118
APPLIED BOUNDARY STRESS σ'_h=106 kPa
ARM 1
ARM 3
TOTAL STRAIN
ARM 2

Fig. 6

Fig. 7

1-D STRESSING OF THE CAMBRIDGE K_o-CELL IN CC



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